# Banksia Woodland Restoration Project

# Annual Report 2

# December 2013

Department of Parks and Wildlife

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**Abbreviations**

- DEC – The West Australian Department of Environment and Conservation (now DPaW)
- DPaW – Department of Parks and Wildlife (formerly part of DEC)
- SEWPAC - the Australian Department of Sustainability, Environment, Water, Population and Communities (Canberra)
- JAH – Jandakot Airport Holdings Pty Ltd
- JA – Jandakot Airport
- BWR - Banksia Woodland Restoration Project (this project)
- TFSC - Threatened Flora Seed Centre (DPaW, Kensington)
- CBC - Carnaby's cockatoo, Carnaby's black cockatoo *(Calyptorhyncus latirostris)*
- TEC – Threatened Ecological Community
- Restoration – Ecosystem Restoration is the "process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed" (SER Primer, 2004). In this report it more specifically concerns establishing a particular type of native vegetation where it is absent.
- Rehabilitation – has a similar general meaning to restoration, but in this report refers more specifically to other actions such as weed management to promote recovery of existing but degraded native vegetation.
- Completion Criteria – numeric targets or milestones for restoration projects used to report outcomes.

## Executive Summary

The Banksia Woodland Restoration (BWR) Project of the Western Australian Department of Parks and Wildlife (DPaW) undertakes restoration work funded by Jandakot Airport Holdings Pty Ltd (JAH) as part of the Commonwealth requirement to offset the impacts of clearing 167 ha of native vegetation at Jandakot Airport in Western Australia. This Department of Sustainability, Environment, Water, Population and Communities (SEWPAC) offset requires JAH to provide DPaW (formerly DEC) with $9,200,000. The role of DPaW is to use these funds for rehabilitation and conservation activities for banksia woodland within 45 km of the airport. This offset is managed by DPaW's Banksia Woodland Restoration Project and the main objectives of this project are to:

1. Restore banksia woodland by creating and repairing lands within the conservation estate.
2. Select areas for management using a ranking process based on environmental values, especially concerning habitats for Carnaby's cockatoos and the grand spider orchid (*Caladenia huegelii*).
3. Use scientific approaches to maximise the cost effectiveness of ecosystem management.
4. Improve methods for rehabilitation using knowledge gained by monitoring outcomes.
5. Maximise the area of banksia woodland restored or managed by efficient resource allocation.
6. Develop monitoring protocols and criteria for banksia woodland condition and biodiversity.
7. Support community groups who help to manage banksia woodlands.
8. Collate and share information on banksia woodland biodiversity and condition.

In September 2011, the Banksia Woodland Restoration project (BWR) initiated large-scale restoration and rehabilitation works on the Swan Coastal Plain in the Perth Metropolitan Region conservation estate. Works undertaken or underway for the BWR project in the first 2 years include:

1. Site ranking and selection giving highest priority to banksia woodland habitats similar to those at Jandakot Airport with highest conservation values and/or with habitat for Carnaby's cockatoos and the grand spider orchid.
2. Establishment of 16 ha of new banksia woodland in cleared areas using topsoil from Jandakot Airport, as well as direct seeding and planting seedlings over an additional 10 ha.
3. Banksia woodland rehabilitation to protect and substantially increase areas in very good condition by:
    a. Weed management of over 500 ha of bushland to control the most serious environmental weeds.
    b. Fencing up to 25 km of reserve boundaries to reduce illegal access and disturbance with associated rubbish dumping, weed and phytophthora dieback spread.
    c. Infill planting of banksia trees in areas where existing native canopy cover is sparse due to disturbance (10 ha).
4. Establishing a network of banksia woodland condition monitoring sites.
5. Providing support for community groups or local government to do any of the above.

The main aim of restoration work is to establish vegetation that is self-sustaining with minimal management inputs for incorporation into adjacent nature reserves that is comprised of local provenance native plants established at appropriate target densities set using reference site data. Restoration reference sites were established at Jandakot Airport (where the topsoil was sourced) and at other areas that were most similar to the restoration sites. Flora surveys of these areas provided data on plant diversity and density which was used to set targets to evaluate restoration success, as well as to plan seed collection and orders from nurseries.

Sites for restoration of banksia woodland in fully degraded areas formerly dominated by weeds were selected at Forrestdale Lake and Anketell Rd Bushland in Jandakot Regional Park, with a planned total area of 50 ha (see Table 1). Restoration of these sites was initiated by topsoil transfer in April-May 2012 and planting of nursery-raised seedlings and direct seeding from 2012 onwards (see Table 1). Direct seeding trials

conducted in collaboration with Greening Australia (WA) in 2012 were successful in establishing tree and shrub cover, so a larger 10 ha area was direct seeded in 2013, with more planned for 2014.

Initial recruitment from topsoil has been promising with 83 native plants identified after the second winter. In total, there are about 110 species of native plants in the restoration sites, from spread topsoil, planting and direct seeding. This compares favourably with plant diversity at the Jandakot Airport reference sites (85 native species). Work to measure completion criteria targets for trees, and understory plants will not be concluded for several years as numbers of topsoil germinants are still increasing and will also be determined by the survival of planted seedlings over summer.

**Banksia Woodland Restoration Actions by Area (areas for activities overlap)**

| Restoration activity | Timing | Anketell Rd (ha) | Forrestdale Lake (ha) | Total (ha) |
|---|---|---|---|---|
| **Topsoil transfer** | 2012 | 11.5 | 4.5 | 16 |
| **Planting** | 2012 | 2.5 | 1.5 | 4 |
| | 2013 | 9 | 7 | 16 |
| | **Subtotal** | **11.5** | **8.5** | **20** |
| **Direct seeding** | 2012 | 2 | 0.5 | 2.5 |
| | 2013 | 10 | - | 10 |
| | 2014 (planned) | 15 | - | 15 |
| | **Subtotal** | **27** | **0.5** | **27.5** |
| **Fencing** | | 10 | 3.5 | 13.5 |
| **Total restoration area** | | **39** | **11** | **50** |

For the past year, the BWR project has worked closely with the DPaW Threatened Flora Seed Centre (TFSC) to manage seed collection and for seed research to resolve problems with the nursery production of some species. A major seed collection for banksia woodland restoration has been established as a key resource for this and other restoration projects (about 400 batches for 68 species, including large 50 batches of tree seed).

The second major component of the BWR project is to undertake site management works to improve the condition of existing banksia woodland in the conservation estate. To achieve this goal a comprehensive weed mapping and prioritisation program was conducted over 20 reserves totalling 1400 ha over the past year. This information was used to select sites for a major weed control project that commenced in 2013 and will continue for several more years. Approximately 330 ha of perennial veldt grass (*Ehrharta calycina*) control was undertaken using grass selective herbicides in 2013 in 20 areas including the two restoration sites. Seven other species of major environmental weeds were also targeted in these areas. The BWR project has also funded major weed management, fencing and planting in 10 of the most important natural areas on the Swan Coastal Plain. These projects were managed by DPAW's Swan Coastal District and Urban Nature Program. In total, weed management projects extend over 600 ha in 23 reserves. Monitoring programs have been established to measure the benefits of weed control on flora and fauna diversity.

A vegetation condition monitoring framework was also established that utilises ground based surveys in conjunction with satellite imagery to help assess vegetation condition in weed management areas and vegetation development in restoration areas. It is anticipated that the project will need to continue planting, seeding and weed control for two more years to reach plant density and diversity targets, while weed control and banksia woodland condition monitoring will require 3 or 4 more years to ensure successful outcomes.

## 1. Introduction and Background

The Jandakot Airport Offset Plan was developed in 2010 by Jandakot Airport Holdings Pty Ltd (JAH) as an offset for the clearing of up to 167 ha native vegetation at Jandakot Airport in Western Australia. The approval for this expansion of Jandakot Airport is subject to a number of conditions, specified in the EPBC 2009/4796 approval document (Government of Australia 2010). The conditions of the approval need to be fulfilled to the satisfaction of the Department of Sustainability, Environment, Water, Population and Communities (SEWPAC). In addition to banksia woodland restoration (Condition 4b), the Offset Plan also provides funding for acquisition and protection of at least 1600 ha of Carnaby's cockatoo feeding habitat (Condition 4c), funding for Carnaby's cockatoo (*Calyptorhynchus latirostris*) recovery actions of $150,000 per year over 5 years (Condition 4e) and $700,000 over 5 years for *Caladenia huegelii* research by the Botanic Gardens and Parks Authority (Condition 6e). Condition 4b requires the payment of $9,200,000 to DPaW (formerly DEC) for the restoration and rehabilitation of banksia woodland within 45 km of Jandakot Airport. A memorandum of understanding between JAH and DEC, signed in 2011, set out the manner in which JAH and DEC will work together to satisfy Condition 4b. In 2011, DEC (now DPaW) initiated the Banksia Woodland Restoration (BWR) project to undertake these tasks.

Approximately 66% of the native vegetation in the Swan Coastal IBRA Region has been cleared, much of which was banksia woodland (Local Biodiversity Program 2013). In the Perth Metropolitan area, less than a quarter of the banksia woodland remains and all of this is recognised as potential Carnaby's cockatoo (CBC) feeding habitat. The BWR project has the overall objective of increasing the area and condition of banksia woodlands, with similar biodiversity values to the Jandakot Airport woodlands, to help mitigate the most significant impacts from clearing of this native vegetation. These impacts include the loss of CBC feeding habitat and some habitat for the endangered orchid *Caladenia huegelii.* The BWR project has the following principal objectives.

1. Restore banksia woodland by creating and repairing lands within the conservation estate.
2. Select areas for management using a ranking process based on environmental values, especially concerning habitats for CBC and *Caladenia huegelii*.
3. Use scientific approaches to maximise the cost effectiveness of ecosystem management.
4. Improve methods for rehabilitation using knowledge gained by monitoring outcomes.
5. Maximise the area of banksia woodland restored or managed by efficient resource allocation.
6. Develop monitoring protocols and criteria for banksia woodland condition and biodiversity.
7. Support community groups who help to manage banksia woodlands.
8. Collate and share information on banksia woodland biodiversity and condition.

The BWR project has initiated large scale natural habitat restoration and rehabilitation work in the conservation estate to meet the objectives listed above. These actions target banksia woodland habitats in the Perth Metropolitan Region, giving highest priority to areas most similar to those at Jandakot Airport as well as areas of very high conservation value such as Threatened Ecological Communities. The process of site selection is summarised in Section 2. Management actions include:

1. Site selection following a rigorous criteria-based ranking process.
2. Establishment of new banksia woodland in cleared areas using topsoil from Jandakot Airport, direct seeding and planted seedlings.
3. Banksia woodland rehabilitation to protect and substantially increase areas in good condition by:
    a. Weed management of bushland to control the most serious environmental weeds.
    b. Fencing of reserve boundaries to reduce illegal access and the associated disturbance and rubbish dumping, as well as weed and phytophthora dieback spread.
    c. Infill planting of banksia trees in areas where existing native canopy cover is sparse due to fire or drought impacts.
4. Establishing a network of banksia woodland condition monitoring sites.
5. Providing support for community groups or local government to do any of the above.

## 2. Site Prioritisation

For this project, restoration sites were chosen after ranking all available locations according to a comprehensive set of selection criteria that focussed on biodiversity conservation values, with ranking outcomes summarised in Figure 1. For restoration using topsoil, two large sites which were open paddocks with only a few scattered native plants were chosen (Figure 2). These two topsoil recipient sites had been purchased by the Western Australian Planning Commission for inclusion into the conservation estate. In addition, some topsoil was also used to restore tracks in Ken Hurst Park (a local government reserve managed by the City of Melville). The site selection process identified vegetation that was most similar to Jandakot Airport and many of these areas are in Jandakot and Beeliar Regional Parks (Fig. 2).

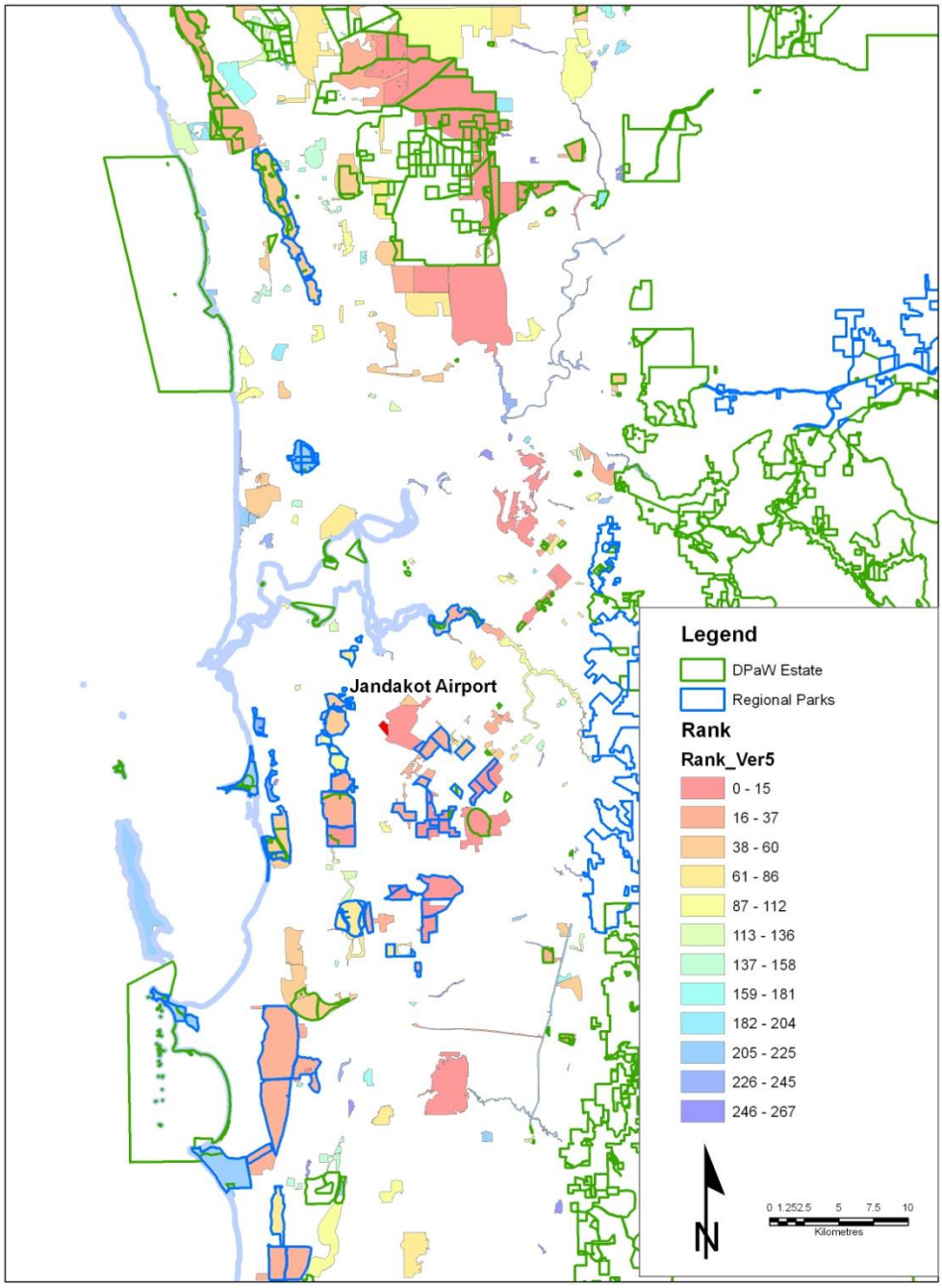



**Figure 1.** Colour coded summary of results of site ranking process, based on similarity to Jandakot Airport and conservation values, for all Bush Forever Sites that was used to select areas for restoration (the highest ranked areas are red followed by orange, yellow, green and blue). The topsoil source area at Jandakot Airport is also indicated (dark red).

## 3. Reference Sites for Restoration Monitoring

Floristic data were gathered from the topsoil source area at Jandakot Airport prior to clearing of native vegetation in 2011. Other reference sites were established in 2012 and 2013 to provide representative baseline plant diversity data for monitoring restoration success (see Fig. 2). These are 10 x 10 m plots used to provide data on the relative abundance, frequency and cover of all plant species. These data were used to assign minimum and maximum density and cover targets for all common species and diversity targets for the minimum number of species returned for functional groups of plants, as explained in Section 7. The same methodology was used for 31 monitoring plots established in 2013 to measure weed management benefits (Section 10). Fauna monitoring has also commenced in some of these plots.

Reference site data was also required to develop target lists for seed collecting and nursery orders, by assigning plants to ecological categories linked to their potential for propagation from seed or topsoil (Section 4). Species considered unlikely to be present in the topsoil seed bank were the focus of seed collecting and nursery orders in 2012 and 2013 (Table 3). Species which are unlikely to recruit from topsoil include the majority of Carnaby's cockatoo food plants and all of the trees, since these have canopy-stored seed.

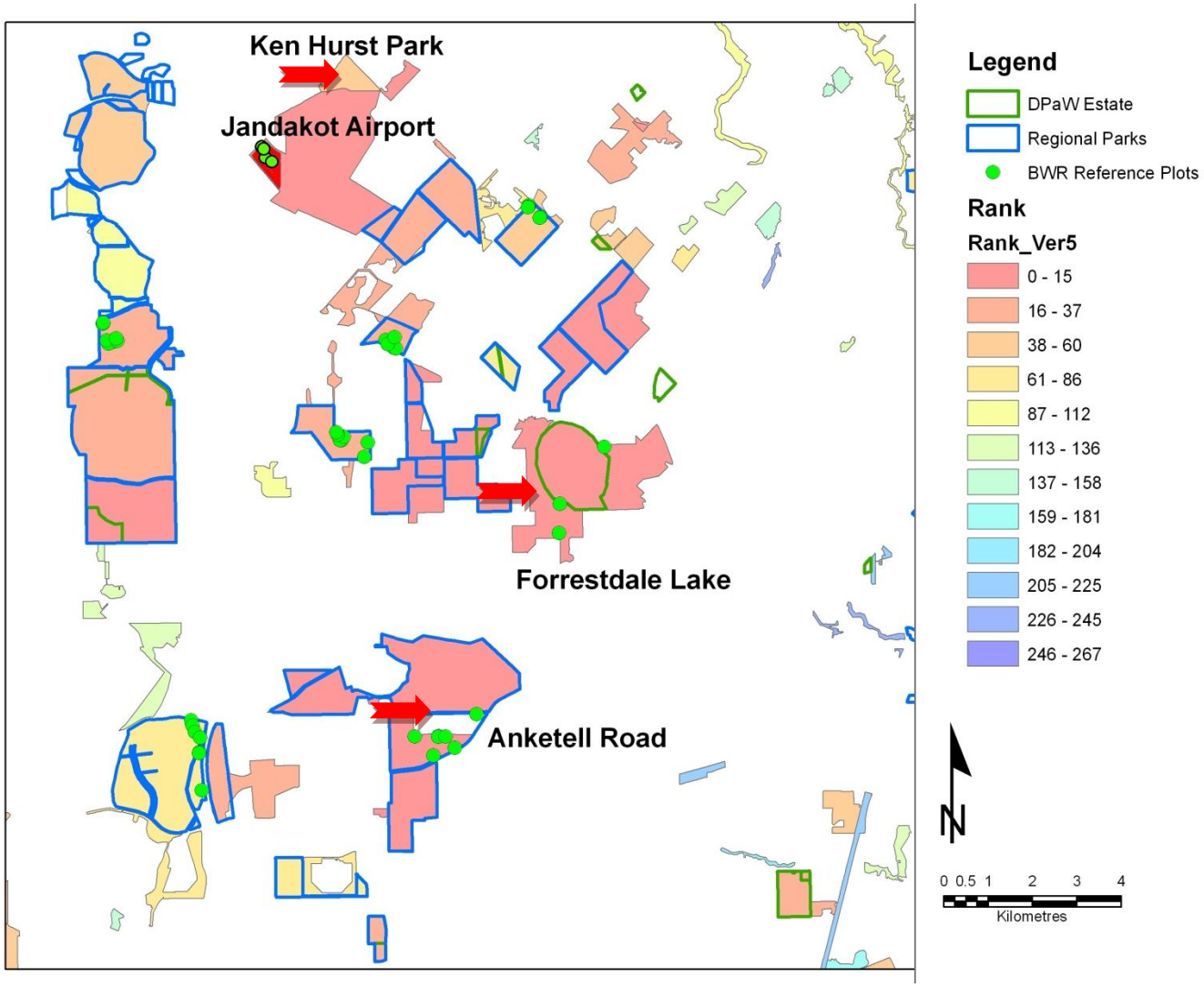



**Figure 2**. The location of reference sites for restoration and weed management (green dots) relative to the topsoil source area at Jandakot Airport (red) and topsoil restoration sites (red arrows). Site rankings for bush forever sites and the boundaries of Jandakot and Beeliar Regional Parks (blue borders) and other reserves in the DPaW estate (green borders) near Jandakot Airport are also shown.

## 4. Seed Management and Storage

Banksia woodland restoration is complex due to the difficulty in predicting species recruitment from topsoil relative to supplemental plantings using direct seeding or nursery grown tubestock. Growing plants from seed can be very difficult, as many species set seed poorly or produce seeds that are difficult to germinate. Seed availability is also a major limitation and seed collecting is a major expense in all restoration projects.

The BWR Swan Coastal Plain seed collections currently contain large amounts of seed from Jandakot Airport and from over 10 other areas to cover a wide range of Swan Coastal Plain plant species and provide a range of provenances for the most important species. These seed collections now include over 380 seed batches, with 50 large batches of tree seed (some over 1 kg). These collections are being stored in a temperature and humidity controlled environment for long term viability. It is expected that there will be sufficient seed for the BWR project and also to supply other DPaW and community group restoration projects from 2013 onwards (Table 1).

The DPaW Threatened Flora Seed Centre (TFSC) has been working with the BWR project since August 2012 to provide seed related technical support and research to help achieve restoration goals. Work by the TFSC has focussed on processing and testing seed batches from commercial seed collectors to send to the nursery, especially for species with low germination due to poor quality seed. This work initially focussed on tree seed, especially banksias, as this was the most expensive to collect due to the brief window of opportunity in early summer. Banksia seed yield data was also used to assess Carnaby's cockatoo food resources in banksia woodland. Species which are common in banksia woodland but known to be difficult to collect or germinate were also a major focus of research. In these cases, seed was often treated or pre-germinated in the laboratory before growth in the nursery (Fig. 3A). Collections for 10 difficult species were also made by DPaW staff (Table 1). In total, 78 seed collections were cleaned, 225 collections quantified, 53 collections tested for germinability and 21 collections tested for dormancy alleviation treatments.

In 2012, about 1 kg of material comprising 19 species was sent to three nurseries (Table 1), resulting in about 13,000 plants (Table 2). Large seed batches were also prepared for direct seeding in 2013, with separate seed mixes for upland and lowland areas. Some species required pre-treatment prior to direct seeding. A separate seed batch was prepared for species not suited to the machinery which were hand spread (Fig. 9B). Nursery orders in subsequent years will be based on monitoring data from the restoration sites and will target species that require infill plantings to reach completion criteria targets. We will also revise how much seed to supply for individual species next year, based on germination data in the field and nursery (see Section 7). The number of each species required will intimately depend on survival of tubestock planted in 2012 and 2013 and recruitment from topsoil and direct seeding which is still continuing.

**Table 1:** Seed batches quantified and tested for the BWR project in 2013.

| Seed | Number of batches | Number of species | Weight (g) | Number of seed or fruit | Pre-germinated seedlings |
|---|---|---|---|---|---|
| **Received** | 388 | 68 | | | |
| **Quantified and assessed** | 225 | 47 | | | |
| **Germination tested** | 76 | 23 | | | |
| **Nursery orders** | 53 | 19 | 1111 | 54,166 | 263 |
| **Direct seeding batches** | 87 | 35 | 6321 | 337,399 | |
| **Additional collections** | 11 | 10 | | | |

**Figure 3A**. Seed viability testing on agar plates at the Threatened Flora Seed Centre (TFSC), was used to help diagnose and overcome problems with poor germination of seed of some species in the nursery.

**Figure 3B**. Seed orders with measured quantities of purified and tested seed were prepared for nurseries and direct seeding at the TFSC. This allows the relative efficiency of propagation methods to be compared and the germination efficiency of each species to be determined, to allow further optimisation in the future.

**Figure 4.** Examples of *Banksia attenuata* and *B. menziesii* seedlings in the laboratory, nursery and field. Seed research was used to overcome inconsistent germination in the nursery. Container size trials in the nursery determined there was better root development in nursery tubes compared to cell trays.

## 5. Nursery Production of Seedlings and Direct Seeding

For the first and second year of restoration at Anketell Road and Forrestdale Lake (2012, 2013), nursery orders primarily consisted of trees and shrubs with canopy stored seed that was unlikely to regenerate from topsoil (see Table 2). Nursery hygiene specifications for seedling production were rigorously defined in a tender document. A total of 20,000 seedlings were ordered from three nurseries, but only about 13,000 were received and planted (Table 2). These differences were due to low seed germination rates for some species (see Section 4), but the majority of species germinated well. In total 6,800 banksia seedlings were planted (Table 2). Planting and seeding in 2012 and 2013 should be sufficient to reach targets for tree density and Carnaby's cockatoo food resources in the areas planted (20 ha), if there are reasonable rates of survival over summer (see Section 8).

Seedlings planted in 2013 were grown in both standard nursery tubes (50 x 120 mm) and larger "super tubes" (67 x 160 mm) to compare larger and smaller root volume at planting (Table 2). The use of larger nursery container sizes in 2013 than in 2012 is expected to result in better summer survival for banksias. In addition to nursery-raised seedlings, 1000 plants of species that cannot be easily propagated by seed were produced by clonal division by a specialist nursery (Ben Croxford at the Nuts About Natives nursery). These species are indicated in the Table 2.

**Table 2.** Nursery raised seedlings planted in 2013. Some banksias were raised in larger super tubes (ST).

| Species | Forrestdale Lake | Anketell Road | Ken Hurst Park | GRAND TOTAL |
|---|---|---|---|---|
| *Allocasuarina fraseriana* | | 158 | | 158 |
| *Allocasuarina humilis* | 209 | 121 | | 330 |
| *Anigozanthos manglesii* | 138 | 492 | | 630 |
| *Banksia attenuata* | 2109 | 2237 | 500 | 4846 |
| *Banksia attenuata* (ST) | 400 | 800 | | 1200 |
| *Banksia ilicifolia* | 10 | 30 | | 40 |
| *Banksia menziesii* | 300 | 287 | | 587 |
| *Banksia menziesii* (ST) | 40 | 92 | | 132 |
| *Conostylis aculeata* | 41 | 169 | | 210 |
| *Dampiera linearis** | 21 | 63 | | 84 |
| *Eremaea asterocarpa* | 39 | 258 | | 297 |
| *Eremaea pauciflora* | 84 | 168 | | 252 |
| *Eucalyptus marginata* | 76 | 270 | | 346 |
| *Eucalyptus todtiana* | 94 | 372 | | 466 |
| *Hibbertia huegelii** | 76 | 210 | | 286 |
| *Hibbertia subvaginata** | 55 | 151 | | 206 |
| *Jacksonia furcellata* | 84 | 253 | | 337 |
| *Kunzea glabrescens* | 72 | 419 | | 491 |
| *Lechenaultia floribunda** | 32 | 94 | | 126 |
| *Lepidosperma squamatum** | 32 | 88 | | 120 |
| *Melaleuca seriata* | 252 | 547 | | 799 |
| *Melaleuca thymoides* | 78 | 154 | | 232 |
| *Nuytsia floribunda* | 24 | 66 | | 90 |
| *Petrophile linearis* | 10 | 24 | | 34 |
| *Phlebocarya ciliata** | 12 | 28 | | 40 |
| *Scholtzia involucrata** | 13 | 29 | | 42 |
| *Xanthorrhoea preissii* | 124 | 707 | | 831 |
| **Total** | **4425** | **8287** | **500** | **13212** |
| **Total banksias only** | **2859** | **3446** | **500** | **6805** |

*Propagated by division

## 6. Restoring Banksia Woodland using Topsoil, Planting and Direct Seeding

In March 2012, a thin layer of existing topsoil was scraped off to reduce weed seed levels, before the arrival of banksia woodland topsoil from Jandakot Airport. Some exotic trees were also removed from Forrestdale Lake to free up additional space for restoration. Topsoil from Jandakot Airport was spread to a uniform depth of either 50 or 100 mm in April-May 2012. These areas were then planted and small direct seeding trials set up in 2012 (Table 3). Larger planting and seeding programs occurred in 2013, as explained below.

Rabbit-proof fencing was installed around all planting areas in 2012, with a total area of 14 ha, except for 1.5 ha fenced with kangaroo and rabbit-proof fencing by Greening Australia. The fenced areas cover most of the topsoil translocated from Jandakot Airport, as well as, most areas planted with tube stock and direct seeded. Spraying of perennial veldt grass in the proposed direct seeding areas occurred in May 2013 to reduce competition for the emerging native seedlings. Planting and seeding did not occur in 36 (13 x 13 m) research plots at each site set up by Pawel Waryszak, a BWR funded PhD student from Murdoch University, in a trial designed to assess germination from the topsoil and various restoration treatments (Figs. 5, 6).

In 2012 about 0.6 ha at Forrestdale Lake and 10 ha at Anketell Road was direct seeded for the BWR project by Greening Australia WA as a trial to assess the effectiveness of direct seeding for establishing banksia woodland (Fig. 8A). This seed drill technology was developed by Greening Australia (WA) and has been used to restore large areas efficiently in other sites. Site preparation prior to direct seeding included scalping and ripping along seeding rows and the application of fertiliser and wetting agent.

In 2013, planting started on Sunday June 16 with a community planting day at Anketell Rd and concluded on July 26. Tube stock was planted over 6 weeks using an Ecojobs (Green Skills Inc.) crew of 4-5 people for 12 days and 3-5 DPaW staff for several weeks. Birdlife Australia volunteers, contacted by Conservation Officer Tamara Kabat, planted trees to provide crucial feeding habitat for Carnaby's cockatoo (Fig. 7A). Planted trees were supplied with a fertiliser tablet (Typhoon slow release 20 g native). Most planting occurred within the fenced areas shown in Figures 5 and 6 and those planted in open areas were protected by open mesh tree guards.

Dieback testing showed that while the majority of nursery raised seedlings were dieback free, one sample contained a relatively weak pathogen (*P. nicotiana*). The holding areas where this plant originated (in a certified nursery) will not be used again. Dieback testing of the field sites has been negative so far, but further testing of these areas will be required as these areas initially lacked susceptible plants and some nearby areas are known to be infested.

**A. Forrestdale Lake**

Areas of Forrestdale Lake spread with topsoil transferred from Jandakot Airport, planted with tube stock and direct seeded are shown in Table 3 and Figure 5. Most areas at the Forrestdale Lake site were planted with both overstorey and understorey species. An additional 5.4 ha outside of the main restoration sites was planted with trees only (mostly *Banksia attenuata*). Most trees in this area were killed by fire in early 2008 and some areas failed to regenerate well (area hatched in Fig. 5B). In addition to BWR project plantings, Greening Australia WA manages two more restoration sites at Forrestdale Lake as part of a Western Power offset. Additional planting and weed management is likely to be required over the next 2-3 years, especially in weed dominated areas at the edges of restoration sites.

**B. Anketell Road**

Areas at the Anketell Road site spread with topsoil transferred from Jandakot Airport in 2012 and those areas planted or direct seeded in 2012 and 2013 are shown in Figure 6. Rabbit-proof fencing extends around 10 ha including most of the spread topsoil, direct seeding and planting areas. In 2013, 10 ha of land suitable for banksia woodland restoration was direct seeded outside areas with transferred topsoil (Fig. 6, Fig. 8A). These areas received supplemental hand seeding of additional species to increase diversity (Fig. 8B). Seeded

species are listed in Appendix 1. It is planned to direct seed additional areas in 2014 (up to 15 ha), using seed from current seed collecting programs. All fenced areas were planted with tube stock in 2013 (Fig. 6).

At both Forrestdale Lake and Anketell Road, separate species lists were used for planting and direct seeding upland and dampland areas. These lists resulted from assessment of flora and vegetation in reference sites that ranked species according to their importance in each zone. The upland and dampland areas were identified using historical aerial photographs and vegetation maps of adjacent areas (Fig. 6A). Topsoil from Jandakot airport was only applied to upland areas, as it contains species unsuited to dampland habitats.

**C. Ken Hurst Park**

The BWR project is working closely with community groups to fund restoration works (e.g. Friends of Ken Hurst Park, Friends of Forrestdale, the City of Melville and the City of Cockburn). In June 2013, 500 *Banksia attenuata* seedlings supplied by the BWR project were planted by the Friends of Ken Hurst Park, as shown in Figure 7B. These trees were planted to replace drought killed trees to help conserve habitat for the rare grand spider orchid *Caladenia huegelii* and Carnaby's cockatoos.

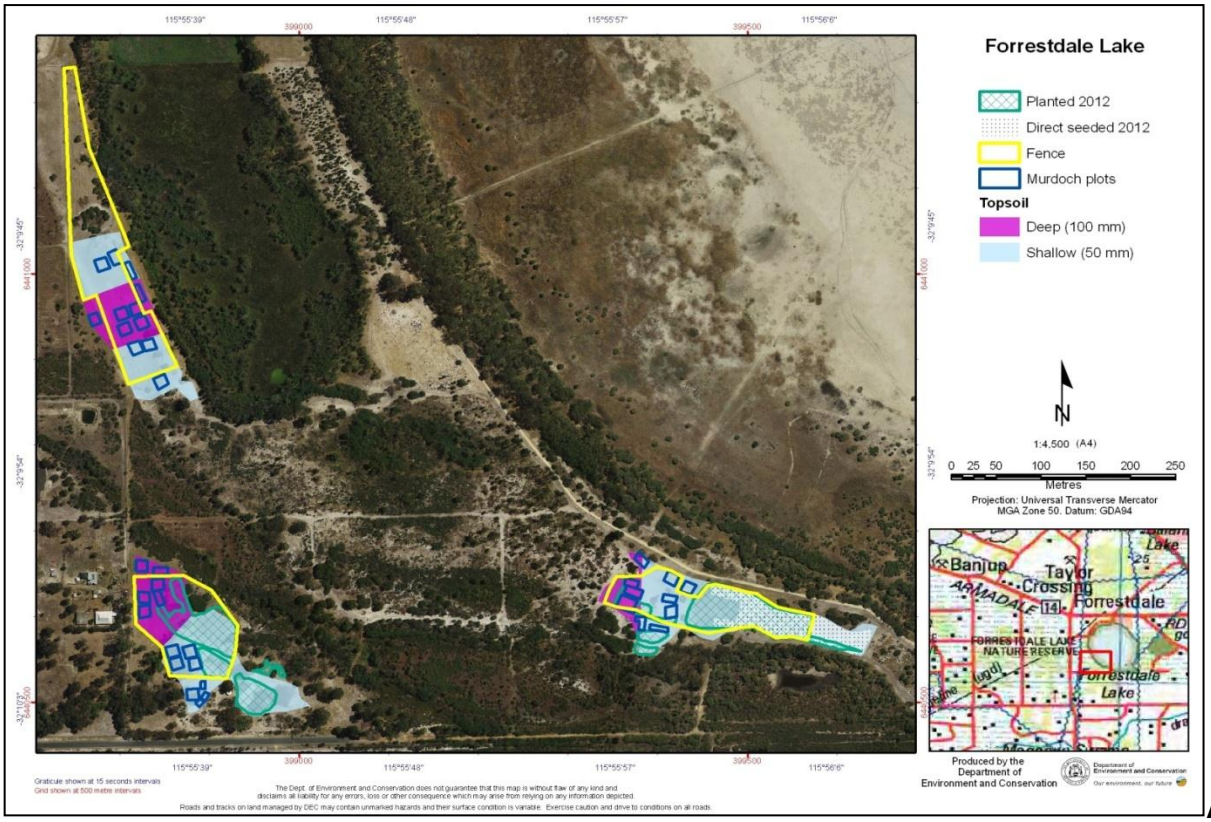
**D. Research Trials**

Continuous improvement in restoration outcomes required some small research trials to be established to validate potential new methods to increase plant establishment in restoration sites, as detailed below:

1. Two pots sizes (standard and super forestry tubes) were used to grow banksias in 2013 to investigate the role of container volume. It was observed that seedlings looked healthier in smaller tubes in the nursery, due to overwatering of larger tubes, but preliminary observations suggest those from larger tubes are growing faster in the field (with more branching).
2. It was noted that survival of heavily grazed banksia seedlings was higher than that of ungrazed plants over summer in 2012/13, so a leaf and root pruning trial was initiated in 2013 in an attempt to increase summer survival.
3. A direct seeding trail to test benefits of wetting agent and slow release fertiliser on summer survival and growth was established using 1000 banksia seeds planted at 2 locations in 2013. Overall, 60% of these seeds germinated within 2 months, but their survival will be reassessed after summer.

**Table 3**. Banksia Woodland Restoration Actions by Area (areas for activities overlap).

| Restoration activity | Timing | Anketell Rd (ha) | Forrestdale Lake (ha) | Total (ha) |
|---|---|---|---|---|
| **Topsoil transfer** | 2012 | 11.5 | 4.5 | 16 |
| **Planting** | 2012 | 2.5 | 1.5 | 4 |
| | 2013 | 9 | 7 | 16 |
| | **TOTAL** | **11.5** | **8.5** | **20** |
| **Direct seeding** | 2012 | 2 | 0.6 | 2.5 |
| | 2013 | 10 | - | 10 |
| | 2014 | 15 | - | 15 |
| | **TOTAL** | **27** | **0.5** | **27.5** |
| **Fencing** | | 10 | 3.5 | 13.5 |
| **Total restoration area** | | **39** | **11** | **50** |

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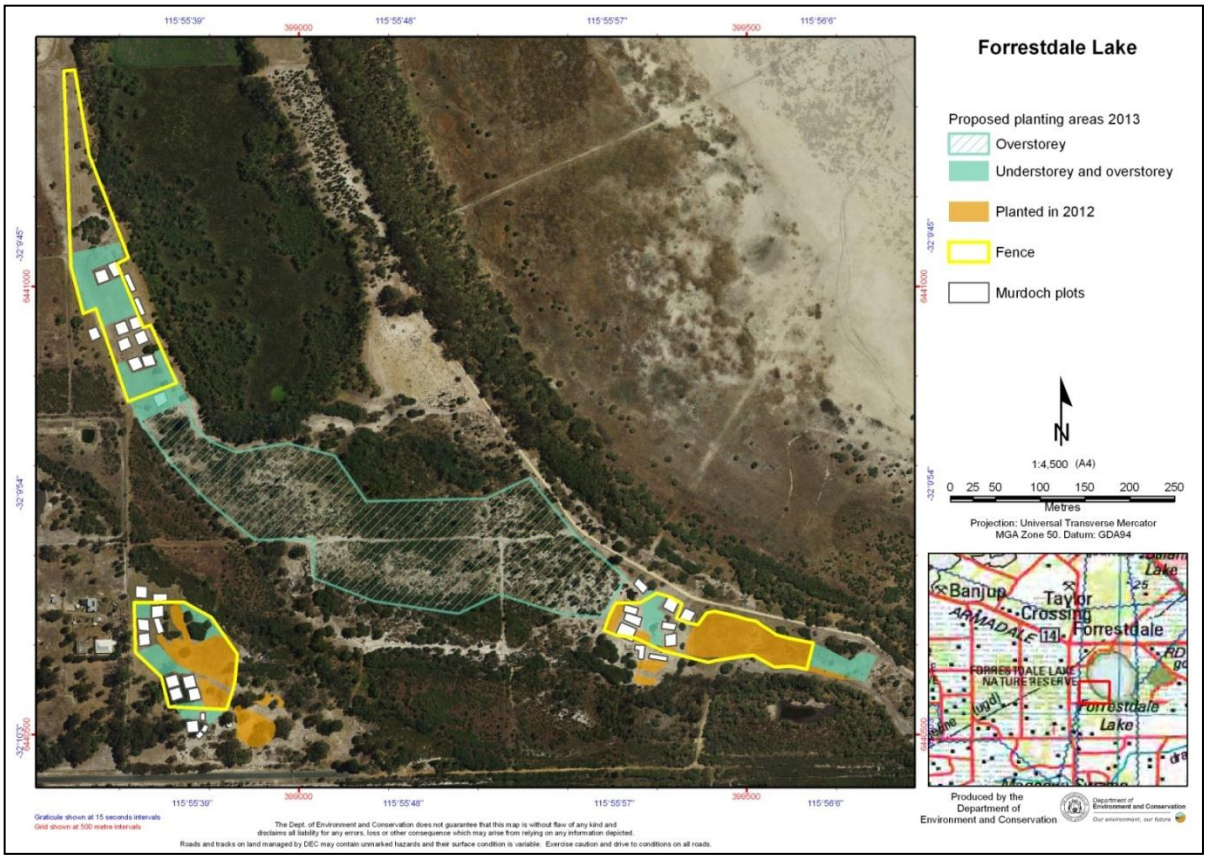
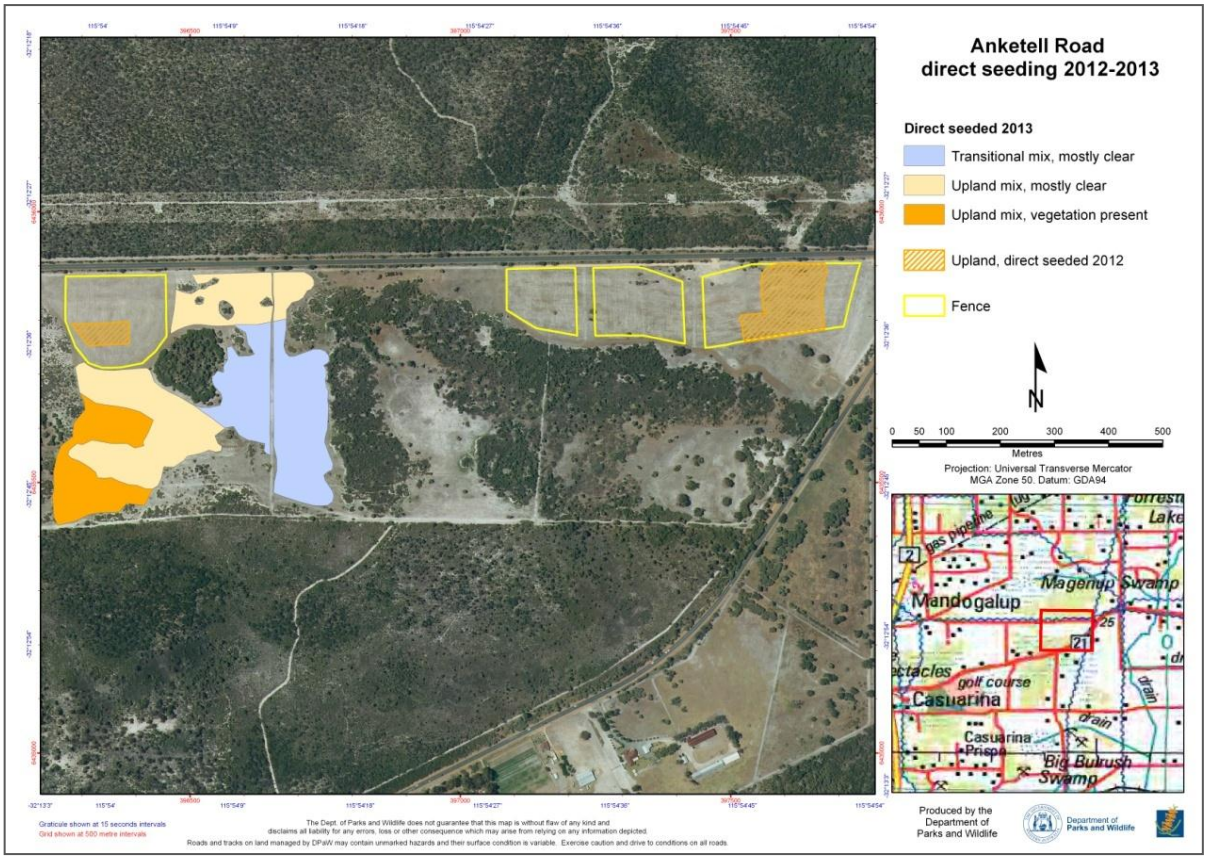
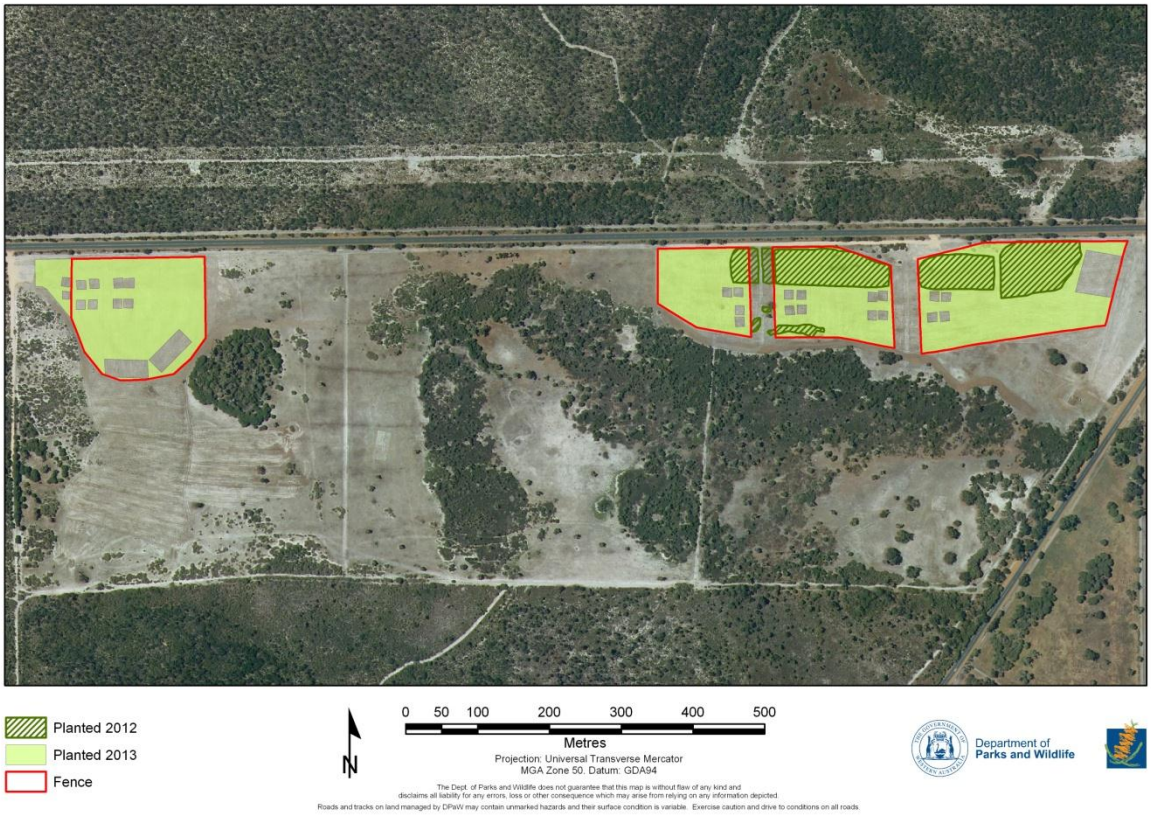



B

**Figure 5. A.** Restoration works completed at Forrestdale Lake in 2012, showing planting and direct seeding relative to Murdoch University research plots. **B.** Tubestock planting in 2013 (green) and 2012 (orange).




A




B

**Figure 6. A.** Anketell Road restoration areas direct seeded in 2013 (solid) and 2012 (hatched). **B.** Anketell Road areas planted in 2013 (green) along with areas planted in 2012 (orange) where some replanting occurred to compensate for summer mortality.

**Figure 7A.** In July 2013 BirdLife Australia Rockingham Interchange volunteers helped us to restore habitat for Carnaby's cockatoos by planting banksia seedlings and other native plants at the Anketell Road site.

**Figure 7B**. In June 2013, the Friends of Ken Hurst Park planted 500 banksia trees provided by the BWR project to help restore canopy for the Grand Spider Orchid (*Caladenia huegelii*).

**Figure 8A**. Greening Australia WA was contracted by the BWR project to direct seed 10 ha at Anketell Rd in 2013**.**

**Figure 8B**. Supplemental hand seeding of species not suitable for machine sowing by DPaW staff.

## 7. Survival of Planted and Direct Seeded Native Plants.

Survival of seedlings planted in 2012 over the first summer was lower than anticipated and the number of seedlings received was also much less than ordered, but a substantial number still survived (see Fig. 9). In total about 1000 seedlings survived out of the 5000 planted in 2012. Most of the surviving seedlings are now growing well and infill planting has replaced missing trees (see below). The relatively low survival, especially of banksias, may have resulted from their nursery production in cell trays. This standard nursery protocol seems to be less suitable for banksias than other species, so we decided to use larger containers to grow all subsequent seedlings. Also, seed quality problems that caused low germination rates for banksias in 2012 have since been overcome (low seed quality and above optimum temperature).

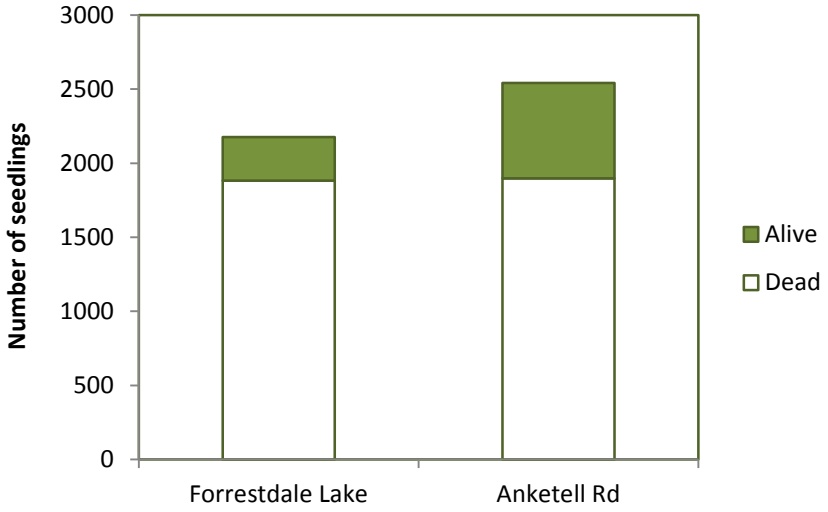



**Figure 9.** Survival of seedlings planted in 2012 after the first summer (May 2013).

Survival rates for three direct seeding trial areas established using a seed drill by Greening Australia in 2012 are presented in Figure 10. In this 2.5 ha total area, about 5200 seedlings were established including about 700 banksias, 1200 eucalypts and 2000 myrtaceous shrubs. Most of these species are not present in the topsoil seed bank, so require planting or seeding (Appendix 1). It was observed that germinated seedlings survived well over summer, except in one small very exposed area at Forrestdale Lake.

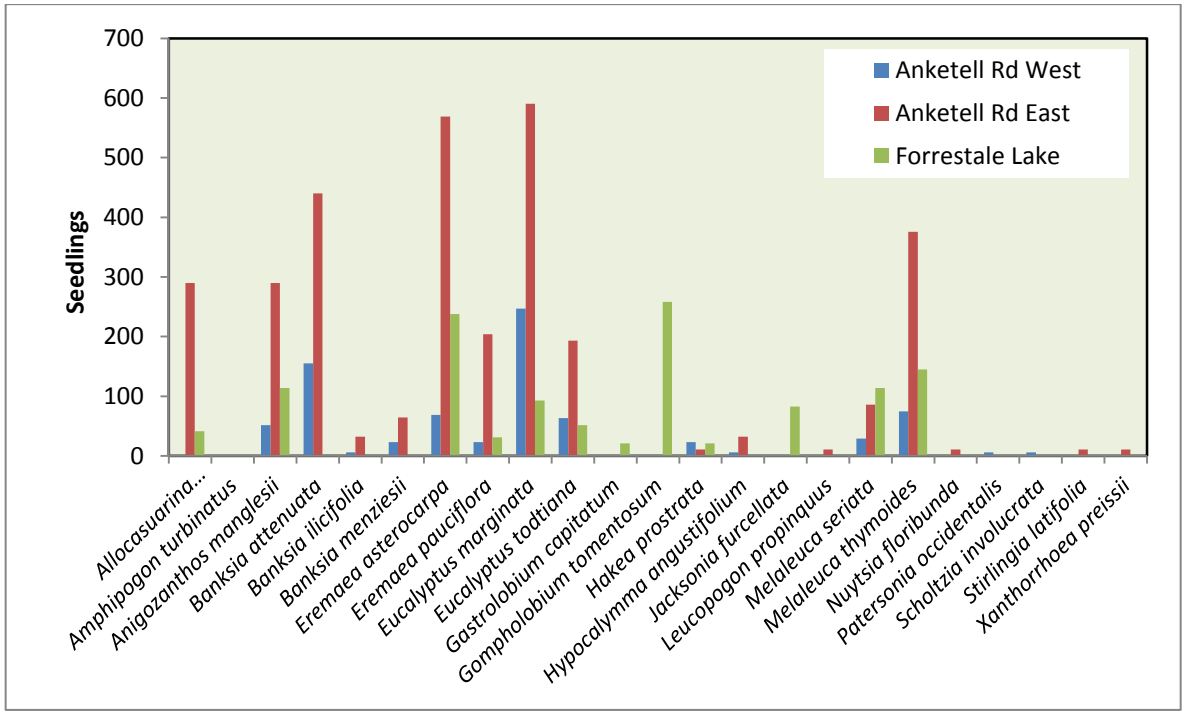



**Figure 10.** Recruitment from direct seeding trails established in 2012 at 3 locations (2.5 ha).

## 8. Monitoring Restoration Outcomes

While monitoring has only commenced recently, there is already sufficient data to show that the diversity of native plants is similar to that found in any one reference site (about 110 native plants as listed in Appendix 1). The majority of native species from Jandakot Airport reference plots have germinated from topsoil in the restoration sites, or are included in the list of planted or seeded species (Fig. 11). It was also noted that 20 or more species were present in restoration sites that were not observed in areas where topsoil was harvested. These additional species include some local opportunists that are spreading rapidly on sites as well as native disturbance opportunists recruited from topsoil. Despite this, there are still a few common native species from references sites that have not been located (or identified) yet and these species will be targeted in future seed collection or propagation efforts, where possible.

There are also about 80 species of weeds present in restoration areas, the majority of which are of limited concern (small annuals or very infrequent). Work to manage weeds is ongoing, with species ranked according to their invasiveness and competitive ability. So far weed management has focussed on perennial veldt grass (*Ehrharta calycina*) control by spraying grass selective herbicide (Section 9) and hand removal of some of the most invasive perennial weeds (all bulbs, *Euphorbia, Pelargonium*, *Carpobrotus*, etc.).

Immediately before topsoil transfer in late spring 2011 and in the spring of 2012 and 2013, we monitored 113 - 1 x 1 m quadrats across the sites to compare species present initially with those emerging from the topsoil. These plots are arranged along six transects 70-100 m long at Anketell Road (53 plots) and nine transects 50-100 m long at Forrestdale Lake (60 plots). Monitoring of these 1 x 1 m plots provided the following results:

- Total native species diversity from the 2013 survey was around 100 species (some of which were still too small to identify beyond family or genus level).The average percentage cover of native species was 3% after 6 months and 4% after 18 months.
- The average percentage cover of weed species was 38% in 2012 and reduced to 14% after veldt grass spraying.

In 2014, the BWR project will set up a series of larger quadrats for planted and direct seeded plants, as well as shrubs recruited from topsoil to compare diversity with reference sites. Each year we also measure the survival and growth of all planted tubestock and direct seeded species, as shown in Section 7. Additional monitoring results will be provided by Pawel Waryszak, a PhD student at Murdoch University, who has trial plots in the area for his PhD study that are being used to measure plant diversity from topsoil-stored seed (see Figs. 5 and 6).

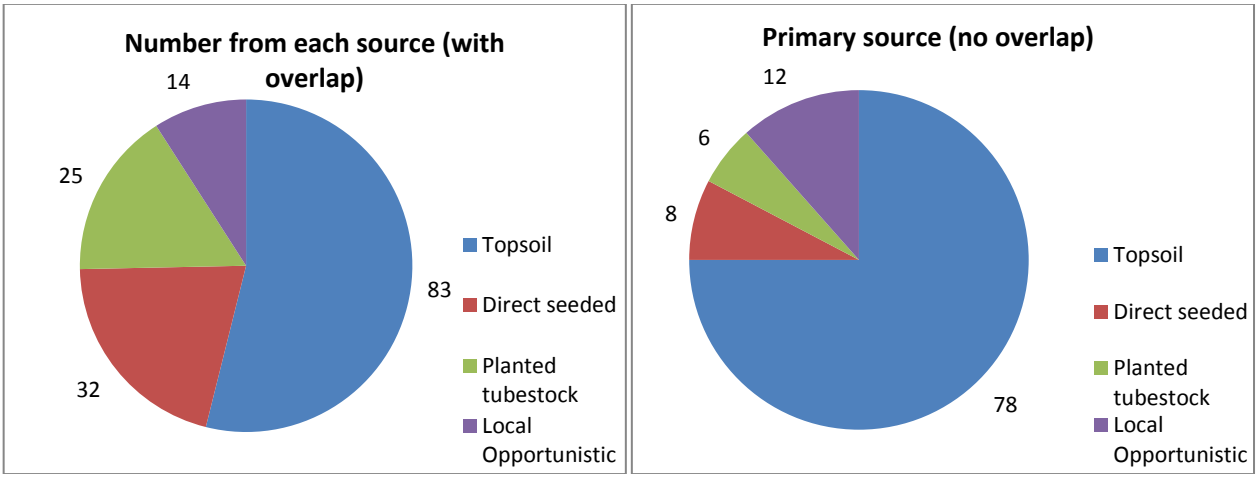



**Figure 11.** The relative proportions of native plants recruited from different propagation sources.

**Figure 12.** Restoration sites in spring 2013 (1.5 years old) showing typical areas with low (left) and high (right) annual native and weed cover. The latter is associated with ripping lines.

Restoration outcomes relative to completion criteria targets are summarised in Table 4. While it is too early to measure some of the key indicators in this Table, other diversity targets have already been reached. In particular, the overall diversity targets for native plants have been reached in many areas, but seed germination from the topsoil was highly variable so there are other areas with more weeds than natives (see Fig. 12). As illustrated in Figure 11, the topsoil seed bank is the main source of ¾ of species present, but this does not include any of the trees and relatively few large shrubs (Appendix 1). Both planting and direct seeding has provided sufficient numbers of trees and large shrubs - assuming adequate survival over the next summer. However, it is necessary to estimate how many trees will need to be planted to reach overall targets by November each year, which is the deadline for nursery orders, long before survival data will be available (May 2014). In fact we need to anticipate survival rates of seedlings several years before they are planted, to organise sufficient seed from seed collectors.

The flora of restoration and reference sites is compared in Figure 13. This ordination is based on species present in reference plots located in banksia woodland sites chosen to be most representative of the soils and landforms of restoration areas (see Section 3). A more comprehensive analysis of floristic differences between restoration and reference sites will occur when plant abundance data is available after current survey work is completed. It is expected that differences between revegetated and reference sites will reduce over time as weeds decline and natives grow, but this difference is already not much greater than differences between some of the references sites (the main differences are due to weed species that only grow well in open areas).

In addition to plant diversity targets, some ecosystem functional targets have also been assessed. It was observed that 17 species flowered and set seed within 1 year (mostly annuals) and about 36 more flowered in the second year, of which many were perennials (Appendix 1). Substantial pollinator activity and seed set was also observed on both revegetated sites within 2 years. The majority of plants forming seed within 2 years are small shrubs, geophytes and annuals. Observations of restoration sites revealed that substantial germination of natives occurred in both the first and second winter, but most geophytes, which presumably grew from tubers or roots transferred in topsoil, did not emerge until the second winter.

A key objective of this project is to evaluate the relative cost effectiveness of different approaches for ecosystem management, especially weed management and restoration of banksia woodland. This will depend on the abundance, diversity, survival and growth of plants recruited from topsoil, direct seeding and planting.

**Table 4.** Targets set to assess plant diversity in restoration sites and preliminary monitoring results.

| Criteria | Targets | Progress to date |
|---|---|---|
| **Overall species richness** | Return 60-80% of native species richness (85 species in topsoil source area at Jandakot Airport (JA) reference plots | **Over 100 species present (but variable spatially)** |
| **Overall Species richness per 10 m x 10 m quadrant** | Return 60% of native species richness as measured in JA reference plots (48 species) | Monitoring required |
| **Tree Diversity** | Presence of all trees at JA reference plots (*Adenanthos cygnorum, Banksia attenuata, B. ilicifolia, B. menziesii, Eucalyptus marginata, E. todtiana and Nuytsia floribunda)* | **All present (planted and / or seeded)** |
| **Tree density** | Establish 300-500 stems/ha | Expect additional planting will be needed after summer |
| **CBC food plants** | This consists primarily of banksias in our site | *As above* |
| **Targets for individual overstorey species** | Stems/ha targets calculated for each species | *As above* |
| **Understorey shrub density** | Establish 7000 stems/ha | Still increasing from topsoil (reassess each year) |
| **Understorey shrub diversity** | Return 60-80% of species richness in JA reference plots (21-28 species per 10 x 10 m plot) | Highly variable across sites and still increasing |
| **Understorey shrub species targets** | Targets set for top 30% (10) most important species from JA reference plots | Most species present (some seedlings not identified yet) |
| **Herbs, sedges, grasses** | Overall targets set for diversity and density, but not for individual species, since it may not be feasible to propagate them | Sufficient diversity of herbs and grasses, but not of some sedges |

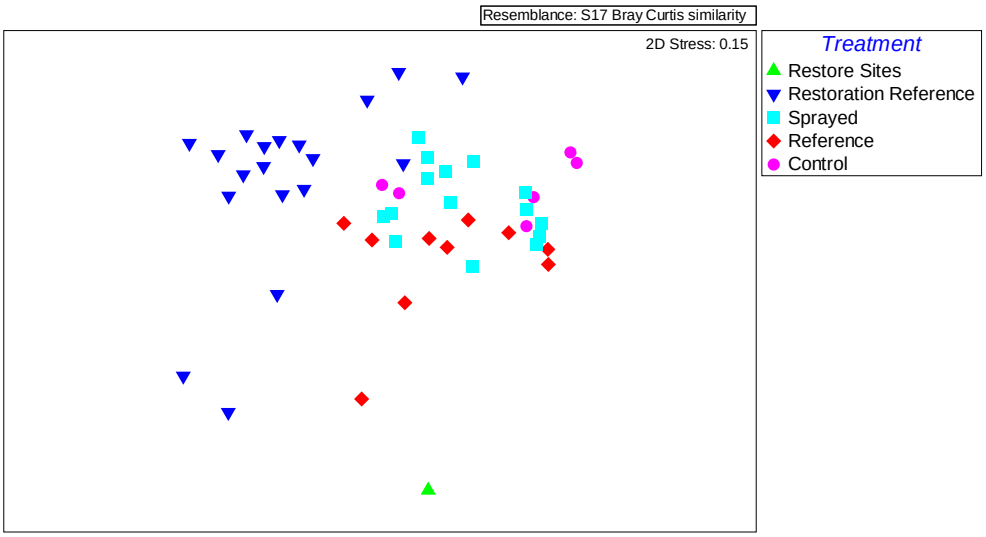



**Figure 13.** Multivariate comparison of flora composition in the 1.5 year old revegetated areas (green triangle) to banksia woodland reference sites for restoration (dark blue) and weed management (other colours).

## 9. Rehabilitation of Habitats by Weed Management and Fencing

The highest priority BWR sites on the Swan Coastal Plain for weed control and other management actions are listed in Table 5. These areas were prioritised by strategic assessment (Section 2), site visits and weed mapping in 23 reserves, of which 16 were newly mapped for this project. Weed management work commenced in 2013 for perennial veldt grass (*Ehrharta calycina*) and other highly invasive weeds. Large areas have also been identified where fencing and gates are required to control illegal access and rubbish dumping (Table 5). This will also reduce the spread of weeds and phytophthora dieback by off-road vehicles in nature reserves. The BWR project has also funded major weed management, fencing and restoration works in 10 of the most important natural areas on the Swan Coastal Plain in projects managed by DPaW's Swan Coastal District and the Urban Nature Program. The weed management objectives set by the BWR project are:

1. Restore ecological values of bushland and key biodiversity assets to a state requiring minimal ongoing maintenance.
2. Select weed species to maximise ecological benefits.
3. Prioritise sites for management based on their environmental significance (Section 2).
4. Undertake management to maintain and/or increase bushland condition.
5. Ensure weed management fits within existing strategic management processes.

In total over 900 hectares of banksia woodland was mapped using a DGPS for the percentage and species of weed coverage for the BWR project, in addition to about 500 ha mapped previously by DPaW and several sites mapped for the City of Cockburn. Following weed mapping a strategic prioritisation process using the objectives listed above was used to select the sites and weed species to target. The principal weed mapped was *Ehrharta calycina* (perennial veldt grass) and approximately 330 ha was sprayed for it this year. In most cases there were clear benefits visible within a few weeks, as suppressed native plants become visible (Fig. 15). We plan to re-assess and respray areas in subsequent years to ensure weeds do not regain dominance from surviving individuals or seed. In total, 20 bushland areas and two restoration sites were selected for weed mapping and weed control managed by the BWR project (see Fig. 14 and Table 5):

1. The two restoration sites, Anketell South and Forrestdale Lake were sprayed first due to the advanced growth rate and early flowering of perennial veldt grass at these sites.
2. A total of 180 hectares was sprayed in Regional Parks (Acourt Road, Anketell North, Anstey Keane, Harrisdale Swamp, Piara Nature Reserve, Shirley Balla, The Spectacles) and Wandi Nature Reserve.
3. A total of 24 hectares of veldt grass was sprayed in Swan Coastal District reserves (Fraser Rd, Hawevale Reserve and Cardup Nature Reserve).
4. The BWR project funded the City of Cockburn to spray a total of 28 hectares on 2 reserves (Rose Shanks Reserve – which is part of the Fraser Road site and Denis de Young Reserve)
5. Spraying at 3 reserves remains incomplete (80 out of 155 ha) due to inclement weather conditions, but these areas should be sprayed next year (Anketell South, Kogolup and Leda Nature Reserve).

In addition to perennial veldt grass, *Euphorbia terracina* (Geraldton Carnation weed), *Freesia alba x leichtlinii* (Freesia), *Babiana angustifolia* (Babiana), *Moraea flaccida* (Cape tulip), *Lachenalia reflexa* (Yellow soldiers), *Watsonia meriana* var. *bulbillifera* (Watsonia) and *Zantedeschia aethiopica* (Arum Lily) have been targeted in the sites listed in Table 5. Each weed species has a specific growth habit which dictates timing and chemical applications required to achieve high mortality rates (florabase.dpaw.wa.gov.au). Spraying was carried out by 5 companies as specified in a DPaW panel tender. The minimum mortality rate of 80% is the standard set for the contractors. Weed control for the 2013 season was seriously impacted by a higher than usual number of rain events that have occurred throughout the winter months, but we still met most of the main objectives with a total of 500 ha managed for major weed infestations.

One of the main focuses of the BWR project is to manage habitat of the grand spider orchid (*Caladenia huegelii*), a rare orchid that occurs in banksia woodland. Several sites were identified where weed management was needed for this endangered species and necessary permits were obtained. These sites were at Wandi Nature Reserve and Fraser Road bushland adjacent to Jandakot Airport.

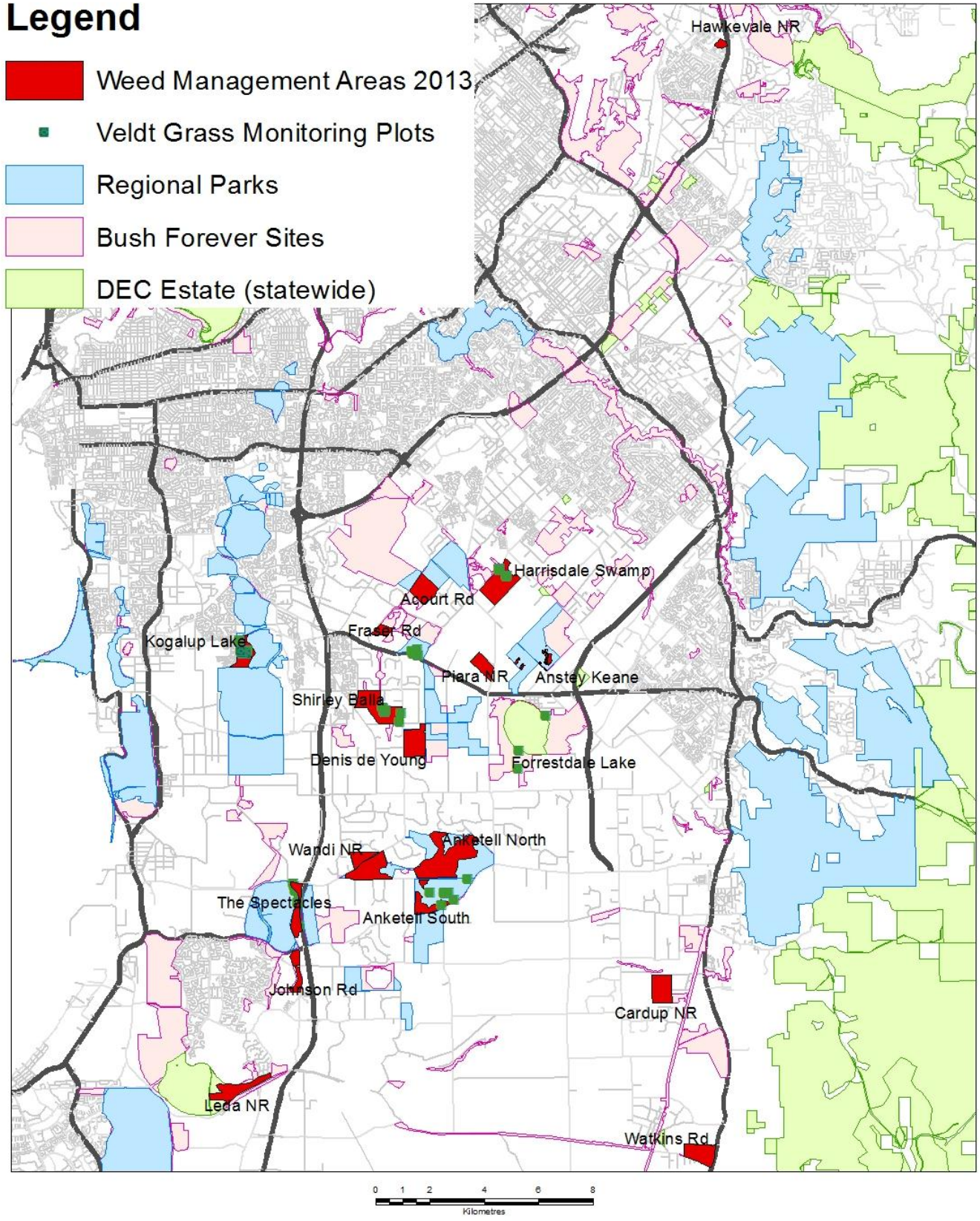



**Figure 14.** Areas where weed management and fencing funded by the BWR project in 2013 have occurred. Monitoring plots for weed management and revegetation reference sites are also shown.

**Table 5.** List of BWR sites for weed control, fencing and other management actions.

| Site Name (Project Management for weeds and fencing*) | Rank | Bush Forever Site No. | Weed mapped area (ha) | Weed management area (ha) | Fencing (km) | Weed management and other objectives |
|---|---|---|---|---|---|---|
| Anketell Rd North, Jandakot Regional Park (BWRP) | 1 | 347 | 204 | 50 | | Veldt grass control, freesia, arum lily, woody weed removal |
| Anketell Rd South, Jandakot Regional Park (BWRP) | 12 | 348 | 51 | 12 (24) | | Veldt grass, hand weeding-euphorbia, pigface, gladiolus |
| Anketell Rd Restoration Site, Jandakot Regional Park (BWRP) | 1 | Adj. 347 & 348 | 18 | 20 | 2.5 | veldt grass control, pigface sprayed (10 ha), hand removal pigface, euphorbia, bulbs, etc. |
| Wandi Nature Reserve, Jandakot Regional Park (UN, BWRP) | 1 | 347 | UN | 20 | | Veldt, freesia, pigface to protect DRF |
| Melaleuca Park (SCD) | 3 | 399 | 53 | 10 | 4 | Euphorbia control, woody weeds and stoping illegal access along Neaves Rd |
| Forrestdale Lake (Friends of Forrestdale, BWRP, SCD) | 4 | 345 | | 10 | repairs | Arum lily, bridal creeper, pampas grass, etc. |
| Forrestdale Lake Restoration Site (BWRP) | 4 | 345 | 6 | 4 | 2 | veldt grass control, hand removal of lupin, euphorbia, bulbs, etc. |
| Lowlands (Private Property, UN, SCD) | 5 | 368 | UN | 50 | | Arum lily, castor oil and cotton bush. |
| Greater Brixton St Wetlands (UN, SCD) | 7 | 387 | UN | 10 | 0.35 | Ongoing eradication of bulbs, bamboo, couch grass. in TEC, fences and gates |
| Dennis de Young Reserve, Jandakot Regional Park (City of Cockburn) | 9 | 344 | CoC | 20 | | Veldt grass and euphorbia (City of Cockburn) |
| Anstey/Keane Dampland, Jandakot Regional Park (UN, BWRP) | 15 | 342 | UN | 50 | | Veldt grass, euphorbia, cape tulip, black flag, Victorian teatree |
| Acourt Rd Regional Park, Jandakot Regional Park (BWRP) | 19 | 389 | 67 | 20 | | Veldt grass, freesia, pampas grass, unauthorised access |
| Kogalup Lake, Beeliar Regional Park (BWRP) | 21 | 391 | 60 | 30 (56) | | Veldt grass, pigface, euphorbia, freesia, watsonia, arum lily |
| Shirley Balla Swamp, Jandakot Regional Park (RP, BWRP) | 22 | 263 | 131 | 30 | | Veldt grass control, euphorbia, bulbous weeds, arum lily and Sydney golden wattle |
| Cardup Nature Reserve (SCD, BWRP) | 23 | 352 | 75 | 10 | 0.5 | Woody weeds in TEC, veldt & love grass control and fencing |
| Watkins Rd Nature Reserve (SCD) | 25 | 360 | SCD | 50 | | Various weeds followed by revegetation |
| Paganoni Nature Reserve, Rockingham Lakes Regional Park (UN) | 33 | 395 | UN | 20 | | Various weeds (follow-up spraying) |
| Neerabup National Park (SCD) | 36 | 383 | | | 1.4 | Fencing and gates |
| Fraser Rd Bushland (SCD, BWRP) | 37 | 390 | 20 | 11 | 2 | Veldt grass control in DRF habitat |
| Rose Shanks Reserve (in Fraser Rd Bushland) (City of Cockburn) | 37 | 390 | CoC | 30 | | Veldt grass control, euphorbia |
| Leda Nature Reserve (SCD, BWRP) | 42 | 349 | 80 | 28 (75) | 2.5 | Veldt grass in prescribed burn area, fencing |
| Harrisdale Swamp, Jandakot Regional Park (BWRP, RP, Friends of Forrestdale) | 43 | 253 | 53 | 40 | | Veldt grass control, dipogon climber, euphorbia, pampas grass, Sydney golden wattle |
| Hawkevale Reserve (SCD, BWRP) | 47 | 122 | 10 | 10 | 0.95 | Veldt grass control, woody weeds, fencing and rubbish removal |
| Piara Nature Reserve, Jandakot Regional Park (BWRP) | 63 | 262 | 36 | 15 | | Veldt grass, euphorbia, arum lily, pampas grass and woody weed control |
| Johnson Rd, Kwinana (SCD) | 69 | 272 | 10 | 2 | | Cape tulip, etc. to protect DRF and other assets |
| The Spectacles, Beeliar Regional Park (BWRP) | 79 | 269 | 50 | 50 | | Veldt grass, arum lily, euphorbia and bulbous weed control |
| Lambkin Rd Bushland (SCD) | 95 | 375 | SCD | 2 | | African love grass, watsonia, etc. |
| **Total** | | | **924** | **604** | **16.2** | |

*Land managers: BWRP = this project, RP = Regional Parks of DPaW, UN = Urban Nature Program of DPaW, SCD = Swan Coastal District of DPaW, CoC = City of Cockburn. Areas in brackets are target areas when different from area sprayed in 2013.


**Figure 15.** Weed management reference plots. **AB.** Weed spraying boundary at Kogolup Lake. **CD**. Photos taken before and after spraying at The Spectacles revealed suppressed natives under the veldt grass.

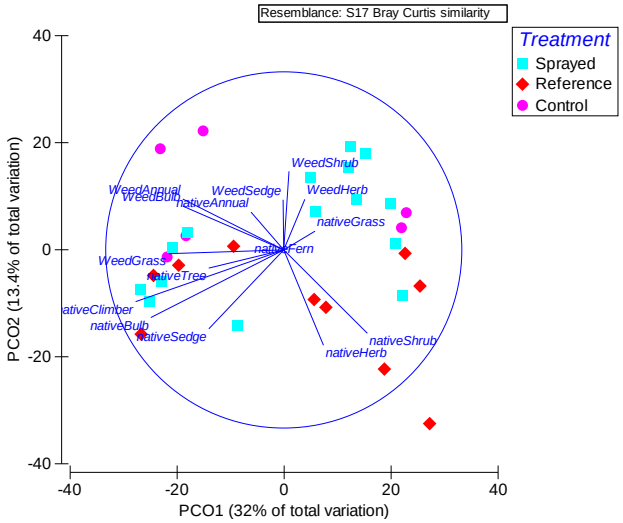



**Figure 16.** Preliminary floristic comparison of sprayed and reference plots by Principal Component Analysis. Correlation vectors (blue lines) show that reference areas chosen to represent good condition banksia woodland (red diamonds) tend to have a higher diversity of native plants than areas with more veldt grass where spraying occurred (blue squares) or that will remain unsprayed (pink circles).

## 10. Monitoring the Condition of Restoration and Weed Management Sites

A banksia woodland monitoring framework was established in 2013 that includes 31 permanent 10 x 10 m plots used to monitor banksia woodland health, animal habitats, plant and animal diversity and to help calibrate satellite data on vegetation condition. One of these plots is shown in Figure 15. The initial floristic comparison of these plots (Fig. 16) shows that perennial veldt grass infected areas tend to have lower

diversity of native plants. A more comprehensive analysis will occur after several years of weed control to measure the impacts of perennial veldt grass on native plants. Reference plots, weed maps and photo reference points are also being used to investigate weed impacts on banksia woodland flora and fauna in some of these plots. Detailed results of these projects will be presented in future reports.

A project to monitor tree canopy and understory vegetation cover and condition is also underway (coordinated by Ricky Van Dongen, Geographic Information Services, DPaW). In both weed management sites and restoration areas, photographs of fixed areas and satellite imagery is used to measure vegetation density at regular intervals to document understory and tree canopy density changes. This project commenced in 2013 and will be summarised in subsequent annual reports.

## 12. Project Management and Governance

Major outcomes from the BWR project relative to objectives and tasks are briefly summarised in Table 7. The Project Management Group which oversees this project consists of the DPaW's Swan Region Regional Manager (Stefan de Haan), Regional Ecologist (Geoff Barrett), Acting Regional Leader Nature Conservation (Barbara Wilson), District Nature Conservation Coordinator (Craig Olejnik) and BWR Senior Ecologist (Mark Brundrett). Meetings are held every 2-4 weeks to organise finances, staffing, collaborations with other organisations, etc. Record keeping and quality control for this project follows standard DPaW protocols and requirements.

The principal stakeholders for this project are SEWPaC and JAH. The BWR project also has developed partnerships with community groups and local governments to effectively manage banksia woodland areas which are listed in Section 13.

A Scientific Advisory Committee (SAC) was formed in 2011 to provide advice on scientific and management aspects of restoration programs such as the BWR project and the Malaga wetland offset project. Membership of this committee is listed in Table 6 and the first four meetings were held in November 2011, May 2012, November 2012 and October 2013. Advice from the SAC primarily concerns:

1. Management of the restoration programs.
2. Habitat restoration research priorities for conservation of biodiversity.
3. Development of criteria for flora and fauna that can be used to assess restoration outcomes.
4. Establishing links with other projects and sharing relevant data.
5. Collection and use of baseline and reference site data for monitoring.
6. Timeliness and progress of the programs and projects.
7. Feedback on reports and major documents produced by the programs and projects.

**Table 6.** Members of the Scientific Advisory Group in 2013.

| | |
|---|---|
| Prof. Richard J Hobbs | Australian Laureate Fellow, School of Plant Biology, University of Western Australia |
| Prof. Neal J Enright | Professor of Plant Ecology, Murdoch University |
| Dr Ben Miller | Restoration Ecologist, Kings Park and Botanic Garden |
| Prof. Mark Tibbett | Restoration Science, Chair of Soil Ecology, Cranfield University, UK |
| Prof. Will Stock | Prof. Environmental Management, Edith Cowan University |
| Dr Mike Bamford, | Consulting Ecologist, fauna expert |
| Dr Katinka Ruthrof | Restoration Ecologist, Murdoch University |
| Stefan de Haan | Regional Manager, DPaW Swan Region |
| Dr Barbara Wilson | Acting Regional Leader Nature Conservation, DPaW Swan Region |
| Dr Mark Brundrett | Senior Ecologist BWR Project, DPaW Swan Region |
| Dr Geoff Barrett | Regional Ecologist, DPaW Swan Region |

**Table 7.** Banksia Woodland Restoration Project objectives and outcomes to December 2013.

| Task | Objectives | Completed |
|---|---|---|
| **I. Administration** | | |
| **1.** Filling Positions | Fill Senior Ecologist, Conservation Officer, Operations Officer, Survey Botanist roles | Five positions filled 2011 -13 and existing staff allocated tasks |
| **2.** Project Management | Hold regular planning meetings to allocate budget and staff to tasks and roles | Meetings held ever 2-4 weeks 2011-2013 |
| **3.** Meeting with Scientific Advisory Committee | Hold meetings to present outcomes and discuss objectives with scientific experts | Four meetings held in 2012 or 2013 |
| **II. Operations** | | |
| **4.** Selection of restoration sites | Choose best site(s) for topsoil based banksia woodland restoration | Two sites selected in 2011 following comprehensive ranking process |
| **5.** Topsoil transfer process | Undertake urgent transfer of 18 ha of topsoil from Jandakot Airport Precinct 5 | Soil transfer concluded in May 2012 |
| **6.** Baseline data collection at JA and reference sites | Collected data for restoration site diversity targets and CBC food value | Data obtained for completion criteria, nursery orders and seed collection |
| **7.** Baseline vegetation data collection and monitoring | Measure weed and native cover data at restoration sites before topsoil transfer | Completed, but monitoring plant diversity and cover is ongoing |
| **8.** Restoration site preparation | Weedy topsoil and exotic tree removal, weed spraying, fencing etc. (20 ha) | Completed in 2012, major weed control and fencing upgrades in 2013 |
| **9.** Experimental design and setup at restoration sites | Targeted research trials established to optimize restoration of banksia woodland from topsoil seed banks, planted seedlings and direct seeding | Research underway: 1. PhD project with Neal Enright and Joe Fontaine at Murdoch University; 2. BWR banksia seedling and planting survival trials |
| **10.** Seed collecting, seed management and germination trials | Obtain seeds required for nursery orders and direct seeding and optimize germination by seed quality investigation | Seeds for 2014 planting sent to nursery and collection for 2015 underway. Seed quality data obtained |
| **11.** Nursery seedlings and cuttings | Produce sufficient tubestock of banksia woodland plants for restoration sites | 13000 seedlings grown and planted in 2013, planning for 2014 planting |
| **12.** Direct seeding and planting native plants | Investigate effectiveness of direct seeding and planting for banksia woodland establishment | Seeding trials in 2012 successful (3 ha), 10 ha seeded in July 2013, areas for 2014 identified |
| **13.** Site selection for weed control and other actions | Identify sites with highest priorities for weed control, etc. and allocate resources | Site visits and ranking process completed in May 2013 |
| **14.** Actions to protect nature reserves from weeds | Control weeds in up to 500 ha with quality control assessment and follow-up spraying as required | Panel tender spraying of 20 reserves, from May 2013 onwards (about 300 ha) |
| **15.** Controlling illegal site access | Fencing to protect banksia woodland from disturbance, weeds and phytophthora dieback | Fencing works underway to protect banksia woodland in reserves |
| **III. Collaborations** | | |
| **16.** Community Group and Local Government | Manage high priority sites with community groups and local government (e.g. Friends of Ken Hurst Park) | Planting days with Birdlife Australia volunteers in July 2013. Support for several projects provided |
| **17.** Banksia woodland monitoring program | Measure health of banksia woodlands in Perth using vegetation, groundwater and remote sensing data | Remote sensing scientific collaboration established in 2013 for 6 references sites |
| **18.** Rare flora monitoring and management | Undertake surveys and manage habitats of rare orchids, especially *Caladenia huegelii* | Works to improve habitats commenced 2011, surveys planned to measure benefits of management |
| **19.** Scientific research program | Research to measure and optimize plant and animal diversity in restoration sites | Second scientific collaboration for phytophthora dieback research |
| **20.** Communications | Provide information to community groups, the public and other stakeholders | Presentations for community groups and press releases for planting days |

## 13. Communication

**Presentations**

Presentations to the public and community groups on the BWR project by Mark Brundrett are summarised below. A meeting held in May 2012 presented information on this project and Carnaby's black cockatoo. Other presentations were for conferences organised by Birdlife Australia and the Wildflower Society of Western Australia in 2013.

1. The Banksia Woodland and Wetland Restoration Project Scientific Advisory Committee
    a. Meetings Nov 2011, May 2012, Nov 2012, Oct 2013
2. Presentations about the project to community groups and an international conference:
    a. Armidale Branch of the Wildflower Society (November 8, 2012)
    b. The Society for Ecological Restoration Australasia Conference (November 29, 2012)
    c. DEC Workshop on completion criteria (January 29, 2013)
    d. Birdlife Australia Carnaby's Cockatoo Symposium (February 19, 2013)
    e. Wildflower Society of WA's Offsets Symposium (February 23, 2013)
    f. Jandakot Regional Park Advisory Committee (March 26, 2013)
    g. Jandakot Community Consultative Committee (August 8, 2013)

**Partnerships**

1. The BWR project is working with Greening Australia WA to jointly manage the Forrestdale Lake restoration site.
2. The Friends of Forrestdale helped plant tubestock and monitor restoration areas.
3. The Friends of Ken Hurst Park restored habitat for *Caladenia huegelii* (spreading topsoil and planting).
4. Birdlife Australia provided volunteers to plant trees in 2012 and 2013.
5. The City of Cockburn funded to manage weeds in two areas in Jandakot Regional Park.

**Publications**

1. Brundrett M, Clarke K, Vanda Longman V. 2012. Setting comprehensive and effective completion criteria for banksia woodland restoration. Society for Ecological Restoration Australasia Conference, Nov 2012.
2. Brundrett M. 2013. Creating New Flora and Fauna Habitats on the Swan Coastal Plain. Bushland News, Issue 85 Autumn 2013
3. Cockburn Gazette. August 14, 2012. Plants restore habitat.
4. The Armidale Examiner. March 1, 2012. Good news for banksia woodlands.
5. Ink and Quoll. August 15, 2013 - Banksia seedlings in Oakford for Carnaby's cockatoo.

**Media Statements (publisher)**

1. February 22 2012, Restoration commences in Perth's southern suburbs (the Armidale Examiner).
2. July 11, 2012, Restoring banksia woodland for Carnaby's cockatoo (Cockburn Gazette).
3. July 2013, Banksia seedlings in Oakford for Carnaby's cockatoo (Ink & Quoll and DPaW Facebook Page).

## 14. References

Jandakot Airport Holdings Pty. Ltd. *Jandakot Airport Offset Plan.* March 2010. (url: www.jandakotairport.com.au/images/cms/content/Airport%20Offset%20Plan%202010.pdf)

Australia Government Department of Sustainability, Environment, Water, Population and Communities. 2010. Jandakot Airport Expansion, Commercial development and Clearance of Native vegetation - EPBC 2009/4796. March 2010.

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**Appendix 1.** List of plants present in revegetated sites the second year after establishment (2013). Species are from the topsoil seed bank, local spread, or from inclusion in planting and seeding in 2012 and 2013.

| SPECIES | First flowering | From topsoil | Direct seeded | Planted tubestock | Local Opportunistic |
|---|---|---|---|---|---|
| *Acacia huegelii* | | 1 | | | |
| *Acacia pulchella* | | 1 | | | |
| *Acacia saligna* | | 1 | | | 1 |
| *Acacia stenoptera* | | 1 | | | |
| *Adenanthos cygnorum* | | 1 | | | |
| *Alexgeorgia nitens* | | 1 | | | |
| *Allocasuarina fraseriana* | | | 1 | 1 | |
| *Allocasuarina humilis* | | | 1 | 1 | |
| *Amphipogon turbinatus* | | 1 | 1 | | |
| *Anigozanthos humilis* | 2013 | 1 | 1 | | |
| *Anigozanthos manglesii* | 2012 | 1 | 1 | 1 | |
| *Austrostipa compressa* | 2012 | 1 | | | 1 |
| *Baeckea camphorosmae* | | | 1 | | |
| *Banksia attenuata* | | rare | 1 | 1 | |
| *Banksia ilicifolia* | | | 1 | 1 | |
| *Banksia menziesii* | | | 1 | 1 | |
| *Boronia ramosa* | 2013 | 1 | | | |
| *Bossiaea eriocarpa* | | 1 | 1 | | |
| *Burchardia congesta* | | 1 | 1 | | |
| *Calandrinia corrigioloides* | 2013 | 1 | | | |
| *Calandrinia granulifera* | 2013 | 1 | | | |
| *Cartonema philydroides* | 2013 | 1 | | | 1 |
| *Cassytha sp.* | | 1 | | | 1 |
| *Centrolepis drummondiana* | 2012 | 1 | | | |
| *Centrolepis sp.* | 2013 | | | | |
| *Chaemescilla corymbosa* | 2012 | 1 | | | |
| *Conostylis aculeata* | | | 1 | 1 | |
| *Conostylis setigera* | | 1 | | | |
| *Crassula colorata* | 2012 | 1 | | | |
| *Dampiera linearis* | 2013 | 1 | | 1 | |
| *Dasypogon bromeliifolius* | 2013 | 1 | 1 | | 1 |
| *Daviesia physodes* | | 1 | | | |
| *Desmocladus flexuosus* | | 1 | | | |
| *Drosera erythrorhiza* | | 1 | | | |
| *Drosera glanduligera* | 2012 | 1 | | | |
| *Drosera macrantha* | 2013 | 1 | | | |
| *Eremaea asterocarpa* | 2013 | | 1 | 1 | |
| *Eremaea pauciflora* | | 1 | 1 | 1 | |
| *Ericaceae spp.* | | 3 | | | |
| *Eucalyptus marginata* | | | 1 | 1 | |
| *Eucalyptus rudis* | | | | | 1 |
| *Eucalyptus todtiana* | | | 1 | 1 | |
| *Gastrolobium capitatum* | | 1 | 1 | | |
| *Gnephosis angianthoides* | 2013 | 1 | | | |
| *Gompholobium tomentosum* | 2012 | 1 | 1 | | |
| *Gonocarpus pithyoides* | 2013 | 1 | | | |
| *Grass (others)* | | 1 | | | |
| *Grevillea vestita* | | 1 | | | |
| *Haemodorum spicatum* | | 1 | 1 | | |
| *Hakea prostrata* | | | 1 | | |
| *Hardenbergia comptoniana* | | | | | 1 |
| *Hemiandra pungens* | 2013 | 1 | | | |
| *Hibbertia huegelii* | 2013 | | 1 | 1 | |
| *Hibbertia hypericoides* | 2013 | 1 | | | |
| *Hibbertia subvaginata* | 2012 | 1 | | 1 | |
| *Homalosciadium homalocarpum* | 2012 | 1 | | | |

| | | | | | |
|---|---|---|---|---|---|
| *Hovea trisperma* | **2013** | **1** | | | |
| *Hyalopspermum cotula* | **2013** | **1** | | | |
| *Hypocalymma angustifolium* | | **1** | **1** | | |
| *Jacksonia furcellata* | | **1** | **1** | **1** | **1** |
| *Kennedia prostrata* | **2013** | **1** | | | |
| *Kunzea glabrescens* | | **1** | | **1** | **1** |
| *Laxmania ramosa* | **2013** | **1** | | | |
| *Laxmania squarrosa* | **2013** | **1** | | | |
| *Lechenaultia floribunda* | **2013** | **1** | | **1** | **1** |
| *Lepidosperma squamatum* | **2013** | **1** | | **1** | |
| *Levenhookia stipitata* | **2012** | **1** | | | |
| *Lobelia tenuoir* | **2012** | **1** | | | **1** |
| *Lomandra caespitosa* | | **1** | | | |
| *Lomandra hermaphrodita* | | **1** | | | |
| *Lyginia sp.* | | **1** | | | |
| *Macarthuria australis* | **2012** | **1** | **1** | | **1** |
| *Macrozamia reidlei* | | | **1** | | |
| *Melaleuca seriata* | | | **1** | **1** | |
| *Melaleuca thymoides* | | **1** | **1** | **1** | |
| *Microtis media* | **2013** | **1** | | | |
| *Myrtaceae spp.* | | **3** | | | |
| *Nuytsia floribunda* | | | | **1** | |
| *Patersonia occidentalis* | **2013** | **1** | **1** | | |
| *Persoonia saccata* | | **1** | | | |
| *Petrophile linearis* | | | **1** | **1** | |
| *Phlebocarya ciliata* | | **1** | | **1** | |
| *Phyllangium paradoxum* | **2012** | **1** | | | |
| *Phyllanthus calycinus* | **2013** | **1** | | | |
| *Platysace filifolius* | | **1** | | | |
| *Podotheca angustifolia* | **2012** | **1** | | | **1** |
| *Podotheca gnaphalioides* | **2012** | **1** | | | **1** |
| *Poranthera microphylla* | **2012** | **1** | | | |
| *Quinetia urvillei* | **2012** | **1** | | | |
| *Saevola repens* | | **1** | | | |
| *Scholtzia involucrata* | | **1** | **1** | **1** | **1** |
| *Senecio condylus* | **2012** | **1** | | | **1** |
| *Siloxerus humifusus* | **2012** | **1** | | | |
| *Stirlingia latifolia* | | **1** | **1** | | |
| *Stylidium brunonianum* | **2013** | **1** | | | |
| *Stylidium piliferum* | **2013** | **1** | | | |
| *Synaphea spinulosa* | | **1** | | | |
| *Thysanotus arbuscula* | **2012** | **1** | | | |
| *Thysanotus sp* | **2013** | **1** | | | |
| *Trachymene pilosa* | **2012** | **1** | | | |
| *Wahlenbergia gracilienta* | **2013** | **1** | | | |
| *Wahlenbergia preisii* | **2013** | **1** | | | |
| *Xanthorrhoea preissii* | | | **1** | **1** | |
| *Xanthosia atkinsonii* | **2013** | **1** | | | |
| **Total** | **53** | **85** | **32** | **24** | **16** |
| **Overall Total** | **104** | | | | |